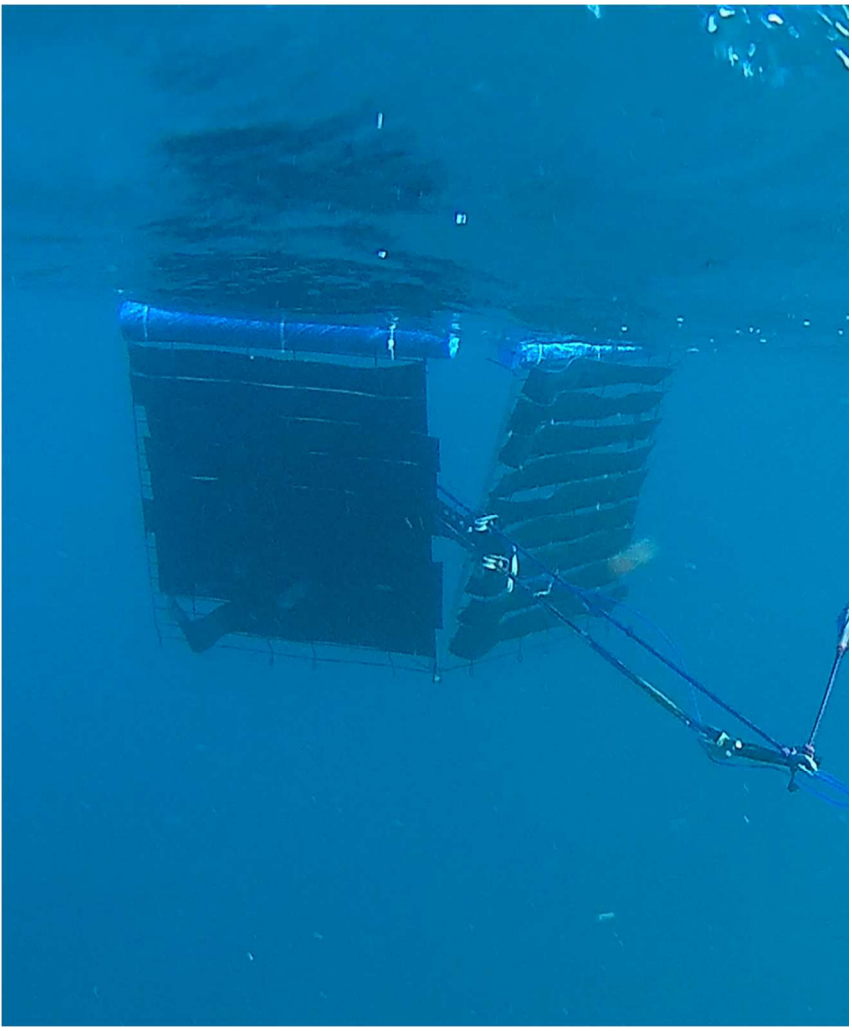


Long Line Wave Energy Converter 2018

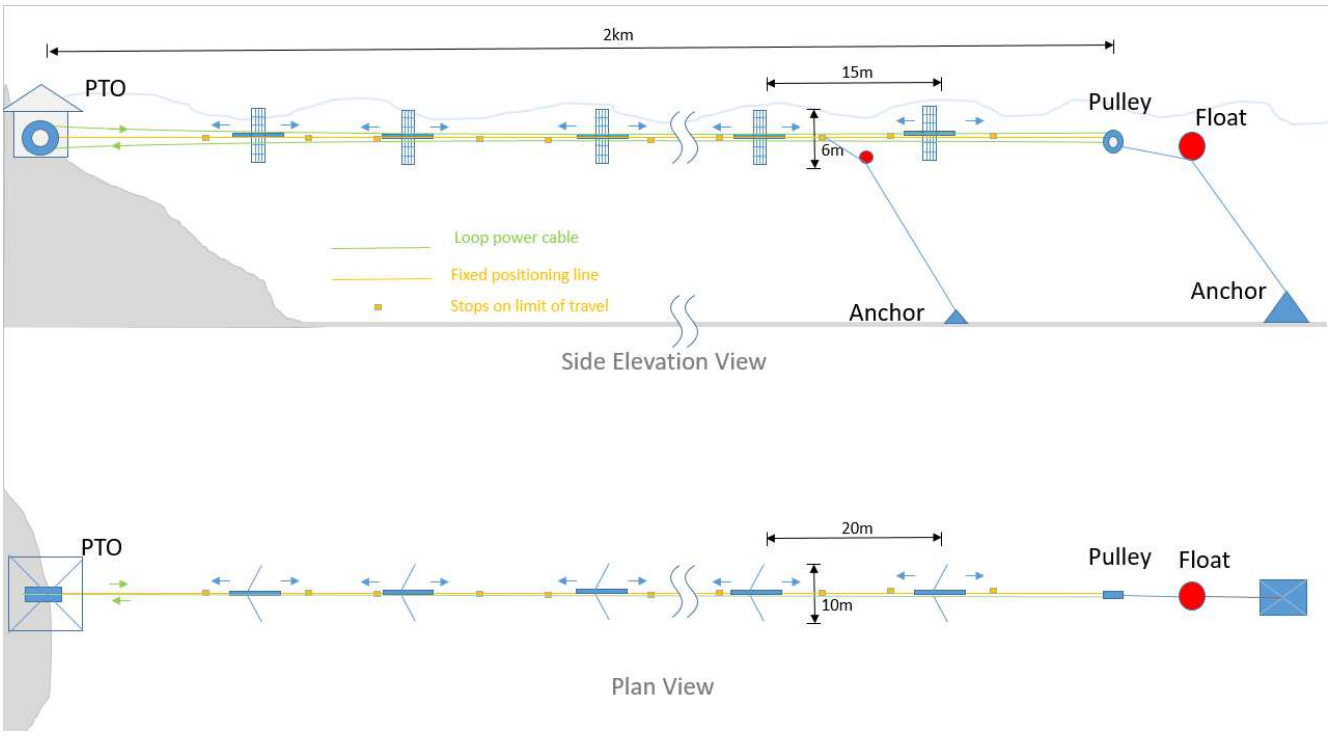
18 December 2018

Cranley Tech

Efforts to date

Development so far has concentrated on the study of the extensive prior art on wave energy conversion. A review of the array of devices that have been proposed and tested, yielded a design which addresses the significant barriers to the commercial success of a wave energy device. A wave energy converter (WEC) concept has been developed, materials reviewed and small scale testing undertaken. The small scale testing confirmed the physical operation of the concept was as expected.

The LLWEC Concept



A video explaining the concept had been developed and is available here https://youtu.be/v-lJkeRHzAE. The device, called the Long Line Wave Energy Converter (LLWEC), consists of a line of surging panels which are driven shoreward and seaward by the wave action. A high strength loop cable [1] is used to collect energy from the motion of the panels and transfer it back to the onshore Power Take Off (PTO). The panels only oppose the wave motion and pull on the cable when they move away from the PTO.. The panels are made up of many small, hinged flaps that can open to wave motion acting towards the PTO to minimise the opposition to the wave motion. The intent of this is to minimise the need for a high capacity offshore mooring, which is a large part of the

expense of installing a WEC. The main mooring can be installed on land, at or near the PTO, which is much cheaper than installing piles or anchoring at sea. The force is transferred in a straight line from the panels to the PTO. The tension in the cable decreases the further along the cable you go away from the PTO. Therefore, the offshore mooring point need only take the slack out of the loop cable and hold the panels from moving towards the PTO when the flaps are open. The panels have very small surface area in every direction except away from the PTO, which is the direction we want to generate the force in. Other devices utilising a line of panels have been studied [2], the power capture figures presented for the wavepiston device which uses a line of vertical panels may be indicative of the potential power capture of the LLWEC.

The LLWEC is a surging device and benefits from the shoaling effect which amplifies the horizontal wave motion in shallower water [3]. As the device aims to be transparent to wave motion in the direction towards the shore, breaking waves should present less of a threat. that The benefits for a surging devices to operating in shallower water have been studied [3, figure 4]. Depending on the wave period, the power capture may be increased by up to 50% compared to a deeper water surging device.LLWEC also avoids the high cost and fault intolerance of electrical cables in the marine environment. It also avoids the high capital costs and energy losses of hydraulic systems.

A full scale device is envisaged to be a line of 25 to 30, 6m by 6m panels.

1. https://www.dsm.com/products/dyneema/en_GB/applications/ropes-lines-and-slings/ropes-lines-and-slings-cases/fpso-mooring-winches-cidade-de-santos.html
2. http://wavepiston.dk/#documents
3. https://www.researchgate.net/publication/240634012

Materials

Cables

Advances in cable technology make the Long Line Wave Energy Converter possible. Fiber rope technology offers many advantages over traditional steel wire ropes. High strength cables are available with high wear resistant outer layers

Ultra High Molecular Weight **Polyethylene** (**UHMWPE**) offers maximum strength with minimum weight.

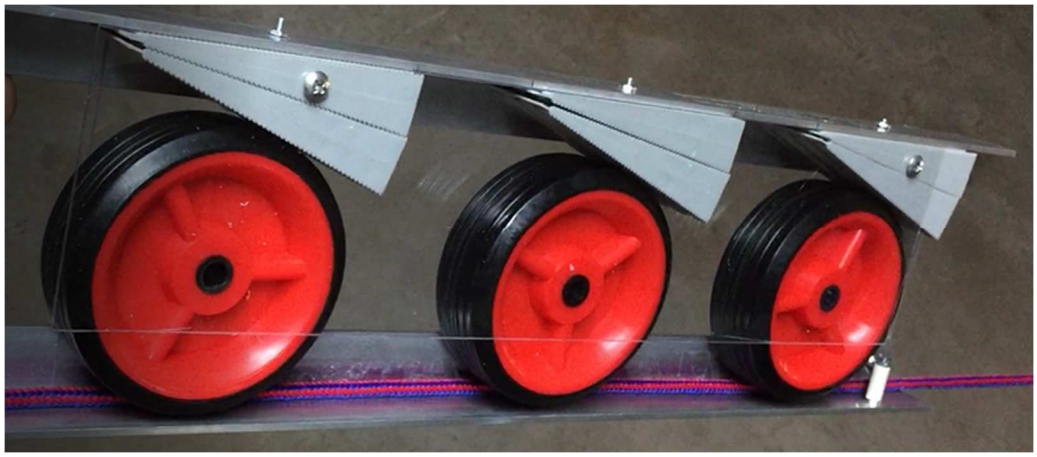
- Ultra high strength versus weight (15 times stronger than steel, like for like)
- Low elongation at break
- High resistance to abrasion, moisture, UV radiation, and chemicals
- Floats on water
- Highly flexible

https://www.dsm.com/products/dyneema/en_GB/science-innovation/science.html

"Go Where Steel Wire Rope Can Not"

Clutch

As the panels only transfer force to the loop cable when moving away from the PTO a cable clutching device is required. Several clutching methods and design are under consideration. Cam, roller, caterpillar track, magnetic and electromagnetic coupling, are being assessed to give the highest component longevity.



https://www.youtube.com/watch?v=yVcQkm4isyE

Anchor

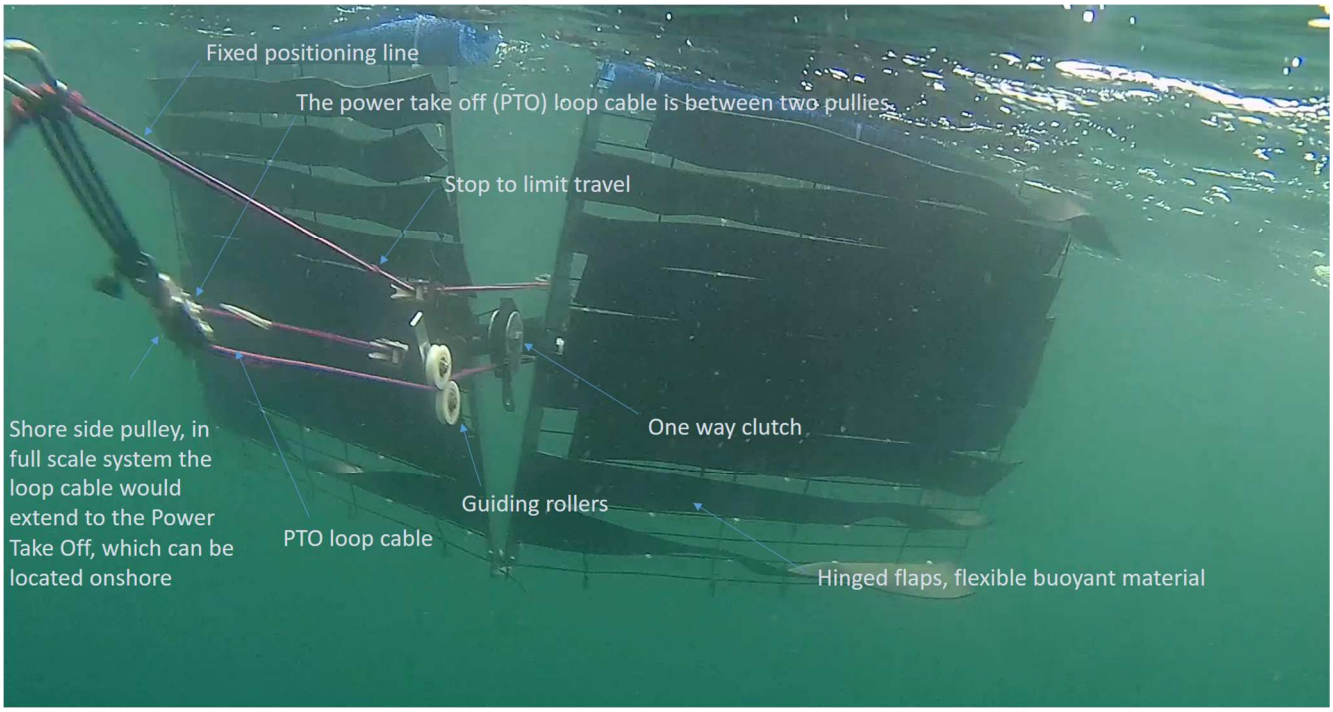
As the device is designed to minimize the forces on the offshore mooring point, an economical drag style anchor combined with a float is sufficient to maintain the device in place and take any slack out of the loop cable. The onshore anchor point must resist the force accumulated in the loop cable. A pile type mooring would be suitable and this is much more economical to do onshore than offshore.

Small Scale Testing

Single Panel Open Water

The physical operation of the LLWEC concept has been validated by small scale sea trials. A single panel has been demonstrated in open water (0.5-1m waves), which confirmed expected operation. See video https://youtu.be/v-lJkeRHzAE at 8min18sec. The panel tested was approximately 1m wide and 0.6m high. A full scale panel will be approximately 6m by 6m. The flaps on each panel opened and closed in response to the changing direction of the water motion as expected. The panel is designed to only oppose wave motion acting away from the PTO direction. This is to minimise the forces on the offshore anchoring point. Although no measurements were taken the tests validated the concept in terms of the observed wave driven motion of the panel.

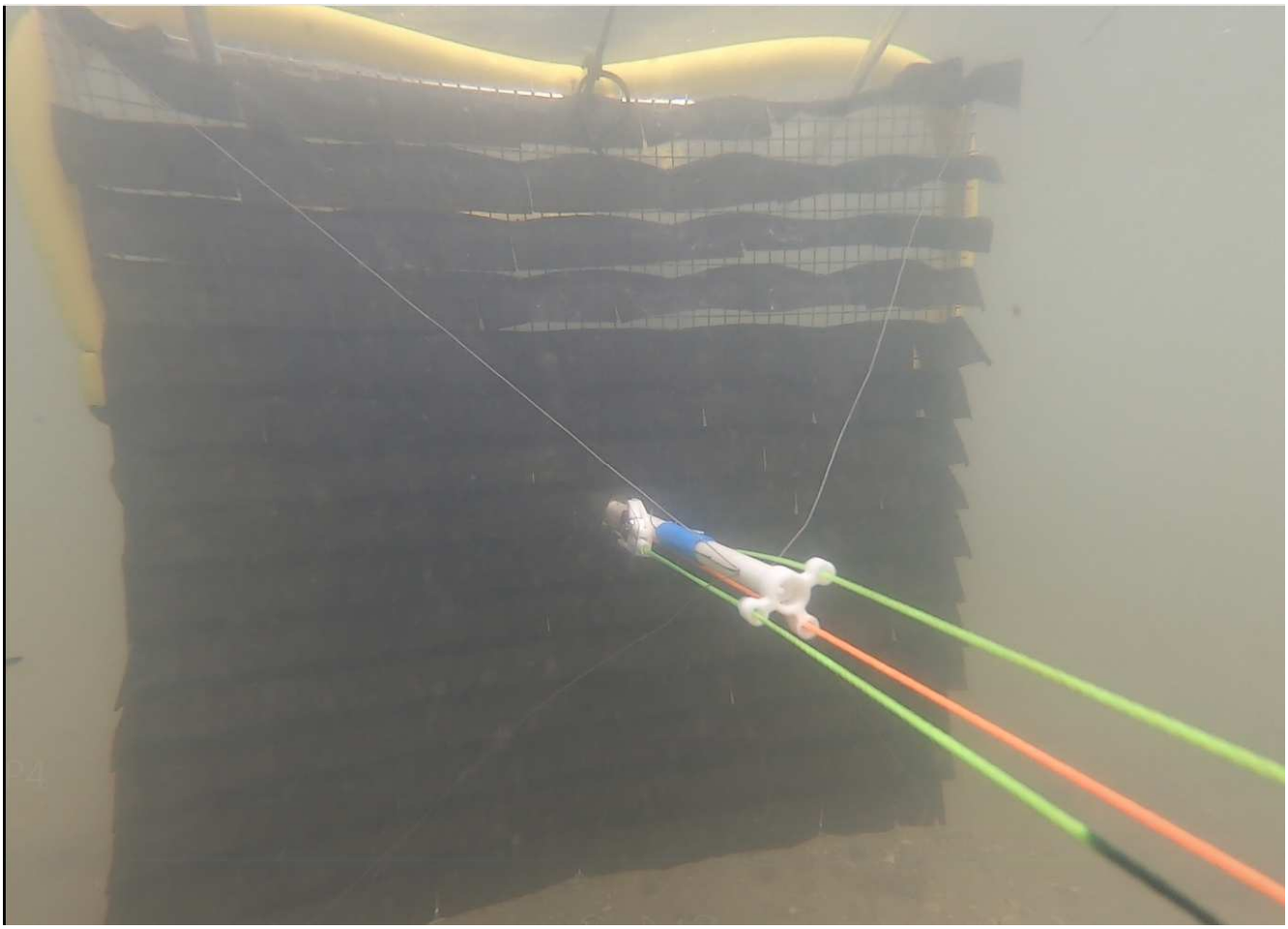
The panel travelled on rollers along a static guiding line. A simple clutch device consisting of a hinged cam successfully gripped the loop cable in one direction and allowed the loop cable to travel freely through the clutch in the other direction. As the motion away from the PTO is opposed and the motion towards the PTO is unopposed the panel tended to travel towards the PTO, confirming the need for the stop fixed to the static positioning line to hold the panel while the flaps open to allow the wave to pass through. The loop cable was driven around two pullyes which simulate the PTO and pulley at the offshore anchor point.


Fixed positioning line
The power take off (PTO) loop cable is between two pullies
Stop to limit travel
Shore side pulley, in full scale system the loop cable would extend to the Power Take Off, which can be located onshore
One way clutch
Guiding rollers
PTO loop cable
Hinged flaps, flexible buoyant material

Line with Multiple Panels

In October 2018, a short line of 5 panels was demonstrated in the sea at 1:20 scale https://youtu.be/6Fdw0dzviH4. A full scale installation would probably have 20-30 panels. The device showed the multiple panels intermittently applying force to the loop cable. A larger number of panels would cause continuous unidirectional motion at the PTO due to the phase difference of the wave force along the length of the line of panels. Although only a smaller number of panels were on the line, as the panels aim to be transparent to breaking waves towards the PTO only a simple lump weight anchor resting on mud was sufficient to hold the device in place. During testing there were several very large waves which did not move the anchor point which highlight how little force was acting on it.

The device demonstrated that the LLWEC could function to produce motion of the PTO line. It also gave experience and highlighted methods of improving the construction of further small scale models.



There will be further demonstrations when available
https://www.youtube.com/channel/UCmxinaQp2U_SLFzGmeMiF7g